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THE INTELLECTUAL SIGNIFICANCE OF THE GRASPING REFLEX

IT is a charge commonly made against the behaviorists that they commit the fallacy of over-simplification, not only when they state their fundamental theories of mind, but also while they attempt to account for complex intellectual and emotional phenomena. To be sure, such a criticism serves more often to reveal the bias of the critic than to show the accused how they might learn from their mistakes, but this is perhaps because the critic has more confidence in his ability to warn than in his skill as a teacher and guide. This same accusation was made in time past against every thinker who had found a new formula by which the muddled confusion of experience might be organized and controlled; for the whole history of modern science is really an account of the supplanting of vague but convenient notions by clear and simple principles derived from a fresh observation of the phenomena of nature. Historically, then, the behaviorists come very well recommended, since today they exhibit that attitude which has always been symptomatic of straightforward progress in science.

The defense of the behaviorist does not, however, consist merely in parrying the blow that is aimed at him; it rather lies in showing the positive errors underlying his opponents' objections. Such errors, moreover, are plainly discernible, and, as we see them, threefold. The first is the inability to perceive that the most complicated effects, both mental and physical, may be produced by extremely simple causes. For just as a tremendously intricate network of froth may be produced by the simple pendular motion given to a soap-shaker across the surface of soapy hot water, so as complicated a "state of mind" as you please may be produced in some individuals by nothing more than simultaneous rises in the temperature and humidity of the atmosphere. Moreover, we have all seen chronically irritable persons the cause of whose disquiet could be traced to a carious tooth, a table too high for them to work at comfortably, direct electric lighting, and so on, while all the time they were entirely unaware of such a circumstance as the sole critical cause of their elaborate mal-functioning. Indeed, we might even say that if such slight environmental changes as these can affect our whole temperament, the behaviorist, far from being over-simple in his explanations, has scarcely gotten the vision of how few the essential phenomena of mind really are.

The second error which the opponents of behaviorism commit is their insistence upon the scientific value of all introspective data whatsoever, and their demand that the behaviorist not only explain these data, but also include them one and all in his scheme of reflex response. The fault here lies in the assumption on the part of the introspectionist that the data which he has amassed are *the chief data* of psychology, whereas they may not necessarily be anything more than the *by-products* of his method. But more than this, the introspectionist fails to see that whenever we introspect, we actually lose contact with the environment of the stimulus. Introspective psychology, therefore, is only a special device for training us to increase the number of verbal associations which any stimulus may arouse. It becomes merely the science of imagery, which is by no means the same thing as the science of thinking, for, as is well known, the presence of imagery does not imply that it will be made use of. And if the introspectionist does not himself always make use of the chosen data of his science, how can he expect that the behaviorist will feel bound to give them a prominent place in his scheme?

The third error of the anti-behaviorists consists in their unchivalrous attitude toward physiology. For while they may be observed time and time again to resort to the nervous system and to the sense organs as a means to explain mental processes, yet when they are pressed about this, they are usually found admitting that all such structures are at best "convenient fictions," never, except possibly in disease, causing or conditioning mental states, but merely affording agreeable, figurative parallels in the shape of center and margin, grades of complexity, or hypothetical spinal levels. The chief difficulty here lies in the interpretation of the human body as an architecture rather than as a "going concern," as a pictorial rather than a dynamic affair, in terms of structure instead of function, of anatomy rather than kinematics. And as this error is fundamental, so are the results of it pervasive.

Perhaps, however, the current toward behaviorism has set so strongly as to make such remarks as these unnecessary to pursue any further. That current, moreover, began to acquire its initial velocity when the first motor theories of consciousness began to be formulated. For the termini of all motor theories are nothing more or less than mechanistic hypotheses such as Crile,[1] for example, has formulated. Even the law of dynamogenesis pointed in just that direction. So that when the behaviorist asserts that the fundamental datum in psychology is reflex response, he is simply announcing the terminus of the trend in all psychology for the last thirty years. The transition is easily traceable from James to Angell, and thence to Judd, and so on to Watson and Holt—nay, the careful reader can detect many a behavioristic utterance in La Mettrie, Lewes, Bain, and Spencer, to say nothing of a dozen other writers both more recent and remote than these last. For once it is admitted that afferent impulses do not stop at the "soul," but proceed straightway to efferent nerves and thence to muscles and glands, and as soon as it is granted that such pathways and structures are essential equally in Medusa and in man, there will be few psychologists indeed who would not seek to complete that hypothesis which Descartes meant to extend over the whole animal kingdom, had not the predicaments of Bruno and Galileo deterred him.

It is not for a moment to be understood that the mere theoretical reduction of mental phenomena to reflexes, or even the establishment of the facts of "action-patterns" or "specific responses" constitutes the whole labor of the psychologist. For even granting that these are the lowest terms of mind, there still remains the larger part of the task yet to be performed, namely, the establishment of the proof that no mental phenomenon can be completely explained without precise and unequivocal reference to the combination and integration of such neuro-muscular reflex responses. This work, strange to relate, now moves far too slowly and heavily. Even behaviorists seem to be unaware of the extent to which it has been halted. Fortunately, it is not difficult to show why this retardation has occurred. It is because the majority of behaviorists have themselves made nothing whatever out of those very factors to which all motor theories of mind indubitably point, namely, the mechanics of muscular action, including the work the skeletal muscle accomplishes to move its bone, and the release or transformation of energy within the muscle which is brought about through the motor nerve. On these matters, which are some day bound to be regarded as equally important with nervous phenomena for behavior psychology, almost every behaviorist remains silent and uncommunicative.

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[1] Crile, Dr. G. W., *Man, an Adaptive Mechanism* (Macmillan). See also his article, "A Mechanistic View of Psychology," in *The Origin and Nature of the Emotions* (W. B. Saunders Co.).

Without going into this matter here any further, except to state that it provides as fertile a field for research as could be desired by the laboratory investigator—in such things as the study of memory postures, the range of imagination possible under certain bodily restraints, *etc.*—let us at once consider whether the reflex response involved in such a simple action as grasping with the hand may not have a far greater significance than we imagine for adult behavior, and even for many so-called intellectual processes. It is the purpose of this paper to exhibit such a connection, and therewith to fully justify the behaviorist against the charge of over-simplification.

The grasping reflex consists of a tendency on the part of an infant to close its hand about any suitable object pressed against its palm, and to cling to that object often for ten or fifteen seconds even if it is lifted so high that the infant is suspended in the air. Watson,[2] who has made a careful study of this tendency, of its varying strength from day to day, and of its disappearance toward the end of the fifth month, states that "in one baby born without a cerebrum the reflex was practically perfect up to the day of its death at 18 days." Twenty-eight observations made on one baby during the first three days revealed what is to all intents and purposes a truly natal tendency to grasp the stick and support the full body weight with either hand. The psycho-physiology of this tendency is important, not solely because the reflex is an index of normality and strength, nor yet because of the fact that the infant *hangs* like a monkey from a limb (for while this hanging freely is a sign of the strength of the instinct, it is not necessarily the sole proof of it), but because of the meaning of such a tendency for adolescent and adult mentality—in a word, for "the learning process called life" in its widest as well as in its most particular signification. But first let us look at the physiological genesis of the reflex itself.

The grasping reflex is a sensori-motor action which begins with the adequate stimulation of the touch spots in the skin of the palmar surface of the hand. This stimulation is carried up to the brachial plexus by the palmar-cutaneous branches of the median and ulnar nerves and is there distributed to the posterior roots of the last four cervical and the first thoracic nerves, whence, after being shot ventrally across the cord, it reappears in the anterior roots and is carried by the motor branches of the median and ulnar nerves again to the various flexor muscles of the palm and fingers.

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[2] Watson, J. B., *Psychology from the Standpoint of a Behaviorist* (Lippincotts), pp. 240, 275.

It is a true spinal reflex, not requiring the cerebrum. The flexor muscles thus innervated quickly contract, the hand is closed about the stimulus and holds it firmly, and indeed, as already observed, with such tenacity that the infant's weight can be lifted into the air and held there unsupported. To this tenacity three principal factors contribute, which we shall now briefly examine.

To begin with, "Flexion is more powerful and complete than extension of the fingers. The *flexor profundus* alone acts on the terminal phalanges; the *flexor sublimis* and *flexor profundus* together flex the proximal interphalangeal joint; and flexion of the metacarpo-phalangeal articulation is effected by these muscles, assisted by the interossei, lumbricales, and flexor brevis minimi digiti. Extension of the phalanges is effected by the united action of the extensors of the digits, the interossei and lumbricales; extension of the fingers at the metacarpo-phalangeal joints is produced solely by the long extensor muscles. *Separate extension of the index finger* only is possible; the three inner fingers can only be flexed and extended together, on account of the connecting bands joining the extensor tendons on the back of the hand."[3] The first reason, then, why the grasping reflex is so powerful is to be found from a consideration of the muscular and bony machinery of the hand itself. For, all teleology aside, the hand is the most *efficient flexion* machine in the body.

Another reason why the grasping reflex is so powerful is revealed by a consideration of the mechanics of the proprio-ceptive system. There are end-organs of muscular, tendinous, and joint sensations which are necessarily stimulated by the flexion-reflex of grasping. The stimulation of these sense organs, either by its being carried clear to the spinal cord or merely to the juncture of the median and ulnar nerves in the forearm, is transmitted back to the flexion muscles to reinforce the contraction already established there. By this mechanism, called the "circular reflex," the muscles automatically reinforce their own contraction. It is not at all necessary to consider that these proprio-ceptive reflexes are provocative of anything *conscious,* since we are countless times entirely unaware of the motions and postures of the skeletal muscles, however important for conscious response they may be. For the behaviorist sharply distinguishes between (conscious) kinesthetic sensations and (unconscious) kinesthetic events in the response process. To be sure, this reinforcement, as well as the flexion reflex itself, may soon wilt, with the result that the infant falls onto his pillow. But such a wilting is only to be expected from both a consideration of the normal duration of any prolonged muscular contraction, as well as from a knowledge of the stimulating effect of gravity upon the extensor system of the hand and forearm. For not only does every peripherally stimulated reflex easily tire on account of the expense to which the body is put to maintain the respiratory exchange in nerve and muscle, but it also happens here that the infant's unsupported position is bound to produce tendinous strains which sooner or later will stimulate spasmodic movements eventually involving the antagonistic (extensor) muscles of the hand. (It is pertinent to remark in passing that while this reflex lasts, it exhibits, as least so far as the behaviorist is concerned, a true case of *attention,* since the flexed posture of the hand is such as to keep the sense organs of the palm adjusted to receive the stimulus most effectively.)

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[3] Cunningham's *Text Book of Anatomy* (1903), p. 336. See also pp. 323–335 for illustrative cuts.

Still another factor contributes to the strength of the grasping reflex in the newly born. For whether it be dogmatic to assert that this reflex is *learned* by the organism during his embryonic life, it seems more than likely that it *is* learned then in the same manner as any other habit or skilful action is acquired by man. For mark, that the infant grasps because his mechanism of prehension is fully developed, and not just because he is *born.* In the light of this observation, which can be safely generalized for all human activities whatsoever, it is doubtful whether any of our behavior should be unqualifiedly termed "instinctive."

This grasping reflex, practically perfect at birth, requires, as we have already mentioned, a precise sensori-motor mechanism, involving, among other things, the median and ulnar nerves. To be more exact, certain of the nervous pathways of the body have become at the moment of birth attuned to function fully and specifically upon the presentation of an adequate touch stimulus to the palm of the hand. Indeed, as soon as the infant is born, the median and ulnar nerves "know how" to perform their characteristic and appropriate—one might almost say *exclusive*—function. Such appropriate functioning requires both time and practise.

Let us venture an explanation of the manner in which this spinal reflex may have been learned.[4] As is well known, the embryo develops characteristically shaped hands by the end of the eighth week of foetal life, which hands, as the embryo proceeds towards maturity, assume a semi-flexed posture which is maintained until the time of birth. At the same time that the hands were being shaped, the muscles were growing in them—each muscle of the flexion set growing with and out into the rudiments of the digits—while the appropriate nerves were steadily prolonged into the various tissues of the hand. When, therefore, the hand attained its final shape, it was supplied with both sensory and motor nerves ready to be coordinated by the first stimulus which should be presented. The nature of such a stimulus, even in prenatal life, is not difficult to conjecture. The embryo's hand, be it remembered, is partly flexed, and its fingers nearly touch the palm. When, therefore, any chance or random movement of the mother's body, occasioned by her walking, sitting, lying down, or rising, disturbs the equilibrium of the embryo, it is more than likely that both its palm and fingers receive entirely adequate touch stimulations. The sensory nerves thus being stimulated, transmit waves of electrical change to the cord, across the synaptic junctions, down the motor pathways, and thence to the end-plates of those muscles which it is the particular business of the median and ulnar nerves to contract, namely, the flexor muscles of the palm and fingers. Such a stimulation is given not once or twice only, but hundreds or even thousands of times, the sensitivity of the palmar surface becoming greater as the muscular contraction becomes more and more pronounced. In this way, we conjecture, the grasping reflex comes to be *learned,* and even by as long a period of practise as three or four months' time. The strength of this reflex may then be attributed not only to the mechanical properties and the proprioceptive mechanisms of the hand, but also to the possibility that the embryo may have unconsciously practised the flexion of the muscles of his fingers and palm.

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[4] For the following suggestion I am indebted to Dr. Edwin Holt.

Now such a sensori-motor reaction, made possible by the factors we have just described, seems to have special value not only for determining the normality of the infant, but also for the life of the growing child and for the social and intellectual behavior of the adult. To begin with, the hand is *par excellence* the active exploratory mechanism whereby we learn the shape of objects. It is not so much with the eye that we educate ourselves to differentiate contours and dimensions, but rather with the palmar surface of the hand and fingers, which contours and dimensions we also appreciate best when the hand is closed or folded about them. To be sure, it is not the *tenacity* of the grasp which functions essentially in our learning about shapes and sizes (since that, indeed, is lost about the 150th day of life), but only the continuous tendency toward flexion with respect to nearly all objects whatsoever which come within the child's reach. The grasping reflex suffers alteration and development of many kinds whereby it enables the child to handle his food-pusher and his spoon, to undress himself, to write, to play ball, and to do a thousand and one more or less useful things. What is lost in tenacity of grip is more than made up in deftness and flexibility. Besides, the reflex is finally so well coordinated with arm, shoulder, and trunk movements, that much of the strain which would be produced in the hand by rowing, driving, and similar operations is nicely distributed over a wide muscular area.

The use of the flexed hand in educating us to perceive the shape of spheres, cubes and octagons indicates, however, only in a small way the intellectual significance of the grasping reflex. For it takes only a scanty research into human activities to reveal that this tendency to close the hand tightly is the basic response in a great variety of widely differing behaviors. Our word *pugnacity* is derived from the latin *pugna,* a fist, that is, a tightly closed fist, a fully functioned grasping reflex. *Boxing, fisticuffs,* and the actions of *shaking, doubling,* or *clenching the fist* are all modifications of this prenatally learned instinct. To be sure, *pugnacity* is not primarily an intellectual accomplishment, but the art of boxing is. There are other kinds of violent behavior which are strictly dependent upon the integrity and development of this same simple response. Our language points to them by such terms as *grabbing* and *snatching, wringing from* and *tearing away, scrambling for* and *pouncing upon,* and *snatching from one's grasp;* while *wresting from, laying violent hands upon,* and other forms of *rapacity* are equally served by this flexion mechanism. Since, also, the grasping reflex is the preliminary step in the making of twisting or torsional arm movements, the *extortioner* and the *grasping miser,* the beggar with the *itching palm,* and the *close, hard,* or *tight-fisted miser* may be mentioned in this same catalogue of derivatives.

Yet even more striking evidence of the importance of the grasping reflex for adult human behavior is found in the use of those terms which signify *physical possession,* not only as far as bare *prehension,* but also as far as the *retention* of either booty or property is concerned. Our words *prehension, prensation,* and *acquisition,* the terms *grip* and *gripe,* as well as the expressions *get into one's clutches,* or *into one's hand, get hold of, gain a hold upon, get into one's grasp, lay or clap one's hands upon,* as well as the proverbial *grasping at straws* in which action the drowning man reverts to his earliest perfected reflex, one and all show how widely the flexion of the hand enters into the struggle for existence and into the mastery over one's fellows. In illustration of the combined action of the grasping and circular reflexes we have such phrases as *keeping hold* *of, clinging to, laying, getting, taking, catching firm hold of,* or *fastening upon;* the words *clench, clutch, clinch, grapple, grab, collar,* and *take by the throat* are similarly derived from this primitive manual action; as well as are the expressions *tight hand,* or *tight grasp, strong hand, making sure of, getting hold,* or *having a firm hold of,* and *getting into one's hand.* The legal term *mortmain,* the proverbial *bird in hand,* and that signifier of failure, *to lose one's grip,* are simply additional proofs not only of the social and intellectual significance of the grasping reflex, but proofs as well in our defense of the behaviorist against the charge of *over*-simplification.

If any additional proofs are needed, it is wise to notice that many of our phrases which signify authority, whether they be classed under the captions of *management, government, despotism,* or *tyranny,* are basically the grasping reflex. Witness such expressions as *get* or *gain the upper hand, pull the strings, have* or *get the whip hand, hold authority, wield the scepter, take the reins of government, Dieu et mon droit* (*i.e., right hand*), *rule with a high, strong, tight,* or *heavy hand, iron hand* or *iron grip, carry with a high hand, rule with a rod of iron,* or *have the game well in hand.* Witness also that one meaning of the term "rights" is also based on the same simple reflex, for " possession is nine-tenths of the law."

What further proofs of the intellectual significance of the grasping reflex could be asked for than are found in a consideration of the functions of such tools as *tongs, forceps, pincers, nippers,* or *pliers?* All these instruments are simply mechanical devices for the performance of those actions which our clenched hands, even though assisted by our finger-nails, can not in their weakness accomplish. But even here our list of derivatives is not completed. For many other activities, some of which refer to the most abstract intellectual operations, ultimately refer to the motor functions of the median and ulnar nerves. *Apprehension* is *catching on,* while *comprehension* is *seizing* for the purpose of estimating. The *emancipated* slave has profited by the *mandate* for his *manumittence.* Things clear to us are *manifest;* cotton cloth is *manufactured;* some primitive boats are *manumittive;* loaded dice are *manipulated;* the author sends to the publisher his *manuscript;* the hand clutches the *mandolin;* the contrabassist " plays by *handfuls* " ; the pervert performs *manustupration;* the convert is given the *right hand of fellowship.* We speak of an *intellectual grasp,* which generically bears more than a superficial resemblance to the *comprehension* of such simple things as shapes and dimensions. Even our mathematical operation of *subtraction* is learned by the child through his *manipulation* of blocks and marbles. Similarly, *abstraction* is a "taking away," that is, acting toward anything *as if* it were made of removable parts. And to close the list we mention that great group of words such as *command, demand,* and *remand,* all of which mean in some important sense the training which the hand has gotten to close over and grasp tightly some adequate stimulus to the sensitive palmar surfaces.

It is thus no long step from the grasping reflex of the newly born to the comprehension by the adult of a mathematical formula. The step is short both to the etymologist and to the behaviorist as well, for the very good reason that they both, whether consciously or not, integrate these many diverse terms and phrases by means of a precise physiological function. Our thesis, then, is that whenever we use these various expressions with the proper signification, they have meaning only to the extent that our coordinated neuro-muscular responses include "action-patterns" involving the motor pathways of the median and ulnar nerves and the muscles of the palmar architecture. That is to say, *we think these various terms* (quoted above) *by means of our hands.* Thought processes are response processes, involving not only sensory and motor nerves, but *muscles* as well, and not only muscles, but also the chemical mechanisms which maintain the respiratory process in the machinery of locomotion. Perhaps the following considerations will render this thesis more intelligible.

To begin with, it is not reputable logic to conclude that just because these various words and phrases which are etymologically derived from the act of grasping are unaccompanied by *awareness* of the hand (*i.e.,* kinesthetic sensations or images of grasping), the use of these words is entirely disconnected from the reflexes involved in the overt act of grasping. I know that many psychologists and most philosophers would flatly deny that the process of *abstraction* or the concept of emancipation, for example, was in any way connected with the stimulation of the palmar muscles, even though they might be willing to admit that some unknown (and undiscoverable) brain process might possibly be involved in such-like thought activities. But it seems nothing short of logical perverseness thus to seek for the explanation of the thought processes in the cerebrum ("the dark throne of mentality itself") when neuro-muscular reflexes and not cerebral events are almost the only things in physiological psychology we have a fixed acquaintance with. Besides, what else can the brain be doing except transmitting stimulation from fibre to fibre?—not a very illuminating explanation for such varied activities as we carry on, even in our thinking! To push the explanation of the thinking process into the obscure is, to say the least of it, both timid and misleading. I do not believe that we need to be so off-hand about the matter. For not only is it absurd to conjecture that because we do not know exactly wherewith we think, we must therefore think with the brain; but it is also untrue to our scientific traditions in physiology not to attempt an explanation of the thought processes in terms of those reflexes which we have everywhere so plentifully under our observation. Astrology became obsolete the moment the law of falling bodies was discovered, and introspectionism became an untenable doctrine the moment the principles of dynamogenesis and reflex action were generally established. And just as we now explain all stellar events by physics, so also we can, I surmise, explain mental events by neuro-muscular processes alone. (I say " neuro-muscular " rather than merely " nervous " processes, for the very good reason that the chief function of the nervous system, so far as we know it, is its activation of muscles and glands.)

How, then, does the grasping-reflex mechanism function in our thinking such concepts as *rapacity, demand,* and *emancipation?* The answer is, I think, extremely simple. There is a law in physiology called the *all-or-none* principle of nerve and muscle, about which Professor Bayliss writes as follows:—

" Nerves can be excited, then, by many and various forms of stimuli and, supposing that the nerve is in connection with some indicator, such as a muscle, different strengths of stimulation are found to produce different degrees of contraction. . . . Now the most careful experiments (see especially those by Keith Lucas, 1909), have shown that the degrees of contraction of a muscle that can be produced by varying the strength of the excitation of the nerve to it, are not as numerous as the degrees of strength of the exciting stimulus, but take place in a series of steps which are no more numerous than the number of motor fibres supplying the muscle. This fact obviously indicates that the varying degrees of contraction are due to differences in the number of muscle fibres in the state of contraction at one time, and that each fibre can only be excited to its maximum capacity or not at all." [5]

The implications of this law for our particular problem as well as for the thought process in general are striking and momentous. For it is a fully defensible hypothesis that " to think of " doing something differs from the overt activity itself chiefly in the number of nerve and muscle fibres involved. Indeed, only on such an hypothesis is imagery of any sort possible. For when a man has a visual, an auditory, or a motor image, he is simply acting *as if* the color, the sound, or the motion were present. Now the all-or-none law beautifully provides a physiological basis for just such an "as-if" reaction. For since every response is, so far as it goes, *maximal* for the number of nervous and muscular elements involved, images may be defined as some of those responses which are carried out on "low gear" by the neuro-muscular mechanisms of the body. Moreover, the safe assumption is that whenever we employ any of these words or phrases which we have previously related to the grasping reflex, and mean anything by them, there is taking place in our median and ulnar nerves and in the flexor muscles of the palm and fingers just such activities as overt grasping would involve, only on a much smaller scale. Theoretically, indeed, as few as a dozen motor neurones from either of these nerves stimulating a dozen muscle fibres in the palm or fingers in some specific pattern of activity would be sufficient to provide any one of these words and phrases with a meaning. And unless we are very much mistaken, something closely akin to this does happen when a man says, for example, "Wait until I get hold of you!" or "I grasp the situation at once." And while this hypothesis is largely a matter of conjecture, I entertain the highest hopes that the electro-physiologist will verify it.

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[5] *Principles of General Physiology,* Longmans, 1918.

If these arguments are sound, and these predictions realized, we shall go a long way toward clearing up many difficulties in behavior psychology. Indeed, the problem of the relation between body and mind will have passed into history. But even before such verification as we hope for, the weight of evidence is overwhelmingly in favor of interpreting the thought process as "a procession of motor attitudes," and by this we mean a neuro-*muscular* process, and not a cerebral mystery. Moreover, we have just shown that the grasping reflex is not merely a reminiscence of tree-life, but an essential, valuable, significant, and permanent factor in our intellectual and social development. Consequently it seems not too much to claim that a proper interpretation of such a reflex mechanism not only serves to acquit the behaviorist of the charge of over-simplification, but it also shows that the simpler the formulas of psychology, the more they explain. For it may well be that the motto of the behaviorist will eventually become: *Give me a nerve and a muscle, and I will make you a mind.*

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